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(54) Fluidized Bed

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This invention relates to a fluidized bed which may for example be used as a heating medium or as heat treatment apparatus which is intended for use in carrying out heat treatment processes on a component or components immersed in the fluidized bed. Thus, where the fluidized bed is to be used as heat treatment apparatus, it is known to provide a bed which is formed of refractory particles, and means for supplying a gas, or gas/air mixtures, which not only provides a sufficient velocity of gas or gas/air flow for fluidizing the bed but which also provides within the bed in use the desired atmosphere for providing the required heat treatment process, it being understood that heat will also be applied to the bed in any convenient manner, for instance by another fluidized bed or in some other way. Examples of such heat treatment processes are carbo-nitriding, oxy-carbo-nitriding, carburizing, neutral annealing, neutral stress relieving, and neutral hardening, the gas or gas/air mixture admitted to the bed having an appropriate composition to provide the correct atmosphere for the required treatment.

It is common practice, in constructing a fluidized bed, to make use of a porous bottom such as may be provided by a porous ceramic tile through which a gas/air mixture can be blown. It is also known to arrange that the gas and air shall be pre-mixed, externally of the fluidized bed, to provide a stoichiometric mixture which can then be ignited so as to provide a burning gaseous mixture which not only fluidizes the bed but also heats the refractory particles of the bed. Ignition initially takes place just above the top of the bed and the flame front then moves downwardly into the bed. Such an arrangement does however present three problems. Firstly, the presence of a stoichiometric gas/air mixture outside the fluidized bed constitutes an explosion risk and fire hazard. Secondly, because a stoichiometric mixture is passing through the porous tile, the flame front will

eventually reach or approach close to the tile and the temperatures to which the tile is then subjected may cause breakdown of the tile material or tile fixing material. Thirdly, the bed will be fluidized by the burning gases whereas in order to obtain good temperature control and optimum fluidizing conditions it is desirable that the fuel input rate and the fluidizing velocity should be independently variable.

One object of the present invention is therefore to provide an improved fluidized bed which alleviates the above-mentioned disadvantages.

In accordance with one aspect of the present invention there is provided a fluidized bed comprising a container having a porous base and containing a mass of refractory particles, conduit means below said porous base for supplying to the underside thereof a non-combustible fluidizing medium whereby said medium can flow, when the bed is in use, through the porous base and into the mass of refractory particles, the layer of refractory particles immediately adjacent to said porous base being formed of denser and/or larger particles than the remainder of said refractory particles so that the particles of said layer do not become fluidized when said fluidizing medium is applied thereto, and further conduit means in said container disposed above and spaced from said porous base for introducing into the container a gaseous medium for use in establishing combustion for heating said mass of refractory particles.

The further conduit means may comprise one or more apertured pipes that are fixedly mounted within said container. Alternatively, said further conduit means may comprise one or more apertured pipes or an apertured pipe grid which is removable from the fluidized bed after the initial heating-up has been effected.

The present invention thus provides in one aspect a fluidized bed where a stoichiometric gas/air mixture is not present outsid the bed and furthermore, by

introducing, above the porous tile, the appropriate amount of air or gas to form a stoichiometric mixture, the porous tile will not be subjected to the highest temperatures because the flame front will not extend on to the upper surface of the tile.

In a further aspect of the invention, protection for the porous tile is provided by arranging that a layer of refractory particles immediately adjacent to the tile is formed of denser and/or larger particles so that this layer will not become fluidized when the lighter and/or smaller particles above are fluidized.

Thus, in accordance with this further aspect of the invention there is provided a fluidized bed comprising a container having a porous base and containing a mass of refractory particles, conduit means below said porous base for supplying to the underside thereof a fluidizing medium whereby said medium can flow, when the bed is in use, through the porous base and into the mass of refractory particles, the layer of refractory particles immediately adjacent to said porous base being formed of denser and/or larger particles than the remainder of said refractory particles so that the particles of said layer do not become fluidized when said fluidizing medium is applied thereto, so that said porous base during use of said bed is thermally shielded by the unfluidized layer of denser and/or larger particles from a fluidized heated layer of the remaining refractory particles which exists above the unfluidized layer during such use.

Still further in accordance with said further aspect of the invention there is provided a method of heat treating articles by immersing them in a fluidized bed comprising a container having a base subject to thermal damage, eg. porous ceramic tile, and containing a mass of refractory particles, comprising the steps of:

(a) arranging a layer of the refractory particles adjacent the base, such layer being of denser and/ r larger particles so

as to remain unfluidized during use, the remainder of said mass of particles being fluidizable;

(b) supplying a fluidizing medium to said base such that said medium flows upwardly therethrough and into said mass of refractory particles at a selected velocity such that said layer of denser and/or larger particles remains unfluidized while a fluidized layer is formed thereabove from said remainder of the mass of refractory particles;

(c) maintaining the temperature of the fluidized layer of refractory particles at a selected elevated temperature with said base being thermally shielded from said fluidized layer by said unfluidized layer of denser and/or larger particles.

The invention will now be more particularly described, by way of example, with reference to the accompanying drawings wherein

Figure 1 is a schematic sectional view of one example of a fluidized bed in accordance with the invention,

Figure 2 is a perspective view of alternative further conduit means that can be used in a fluidized bed constructed in accordance with the invention, and

Figure 3 is a schematic sectional view showing an alternative form of fluidized bed in accordance with the invention.

Figure 4 is a fragmentary schematic view showing in greater detail a part of the construction seen in Figure 1.

Referring firstly to the fluidized bed shown in Figure 1, there is provided a casing 10 having an inner container provided with a corrugated side wall 12 and with a porous bottom in the form of a porous ceramic tile 11

which is conveniently cemented into position. Said corrugated wall 12 is surrounded by one or more layers of heat isulating material 13. There is also provided within said container a mass of refractory particles 14 which in use will be fluidized by a gaseous medium flowing upwardly through said porous tile. The fluidized bed may be intended for use as a heat treatment apparatus in which articles to be heat treated will be immersed in the mass of refractory particles 14 when fluidized and in this case the gaseous medium that is used to fluidize the particles will also provide the desired treatment atmosphere. In Figure 1, said particles are intended to be shown in the fluidized condition and the upper surface of the particles is indicated by reference numeral 15. It will also be necessary to heat said refractory particles and in one application the gaseous medium within the bed may also be used to provide the heat before treatment commences.

There is thus provided beneath said container first conduit means in the form of one or more pipes or passages 16 connectible to a supply of air and a supply of combustible gas. The gas and air are conveniently pre-mixed before they impinge on the underside of said porous tile 11 but in any event the proportions of the gas and air are such that the resulting mixture will be of non-stoichiometric proportions. Preferably such mixture is rich in gas but alternatively it may be arranged to be rich in air.

There is also provided further conduit means which as shown in Figure 1 comprise one or more apertured pipes 17 which are secured in position so that they extend across the bed of particles 14, said pipes 17 being disposed in a position in which they lie nearer to the upper surface of said tile 11 than to said upper surface 15 of the refractory particles. As an alternative to said pipes 17, said further conduit means may comprise, as shown in Figure 2, a removable apertured pipe grid 18 which can be lowered into the bed when desired. Thus, for

example, there may be provided a grid which in plan view comprises a generally rectangular portion 18a together with a further straight portion 18b which interconnects the two shorter sides of the grid and which is parallel to the two longer sides, said further straight portion being connected midway along its length to an inlet pipe 18c which extends in a direction perpendicular to the place of the grid and which also serves as a hanger, the upper end of the said inlet pipe being connectible to a flexible hose (not shown) through which gas or air can be passed. There may also be provided a sheet of wire mesh 19 or like material which is mounted on the aforesaid inlet pipe connected to the apertured grid, said mesh being arranged in a plane parallel to the plane of the grid and being disposed above the grid but at a position so that in use it will also be immersed in the particles 14 so that it acts as a means to inhibit the formation of large bubbles of gas at the top of the bed. The grid itself is formed with a plurality of apertures and with the grid suspended within the mass of refractory particles at a position above but spaced from the porous tile 11 gas or air can flow from the inlet pipe 18c into the grid and thence out of the apertures in the grid and into the refractory particles 14 where it will mix with the non-stoichiometric mixture flowing upwardly from the upper surface of the porous tile 11 so as then to form a stoichiometric mixture. Thus where, as preferred, the non-stoichiometric mixture flowing upwardly through the porous tile from the conduit means 16 is rich in gas, air will initially be blown in through the aforementioned apertured grid 18 or pipes 17 to provide the stoichiometric mixture. On the other hand if an air rich mixture is blown through the porous tile 11 then a further supply of combustible gas is initially injected into the bed through the aforesaid apertured grid 18 or apertured pipes 17.

When the stoichiometric mixture has thus been formed as above described the mixture will flow upwardly

through the bed which will become fluidized by the flow itself and ignition of the mixture can be initially effected just above the top of the bed - i.e. just above the surface 15. As the temperature of the bed increases the flame front will extend downwardly through the bed of particles 14 but will not reach the upper surface of the porous tile 11 itself and the latter, together with the aforesaid cement, will not therefore be subjected to unduly high temperatures. Initial heating of the bed can thus take place as above described and when the desired temperature has been reached, and if the aforesaid apertured grid 18 has been used, it can be removed from the bed whereafter the non-stoichiometric mixture flowing upwardly from the porous tile will provide the necessary treatment atmosphere and also the fluidizing medium. In order however that the grid 18 may be in position prior to commencing operation it can be inserted into the bed whilst the latter is still fluidized just before a prior period of operation finishes. Alternatively the bed will have to be fluidized by the non-stoichiometric mixture blown in from beneath the porous tile before the grid is inserted. It will however be necessary to maintain the desired operating temperature and this can be done by effecting combustion of a gas/air mixture either just above or within the upper part of the bed of refractory particles 14, such combustion zone having the effect of supplying heat to the bed. In Figure 1, there is shown third conduit means in the form of one or more apertured pipes 20 which are disposed just below the surface 15 and which are shown in greater detail in Figure 4. Thus, the or each pipe 20 comprises an upper part 20a which is in communication with a lower part 20b and concentrically mounted within the latter is an inner pipe 20c arranged to carry a non-combustible gas/air mixture. Said inner pipe 20c has apertures 20d in its bottom surface thr ugh which said mixture can pass. Said upper part 20a can be used to convey air when desired so that when a temperature boost

is required after the initial heating, air will be admitted to part 20a by means of a connection (not shown) and will then flow into part 20b and around pipe 20c to mix with the gas/air mixture flowing from apertures 20d. There is now formed a combustible mixture which will flow through the apertures 20e in the bottom surface of part 20b and which will ignite and provide combustion within the upper part of the bed 14. Such combustion can of course be stopped by cutting off the air supply to part 20a or the gas/air mixture supply to the pipe 20c or both of such supplies.

In an alternative arrangement shown in Figure 3, said third conduit means comprises one or more apertured pipes 21 which are disposed just above the upper surface 15 of the fluidized particles and in this case when it is desired to boost the temperature of the fluidized bed, air or a gaseous fuel, as the case may be, is blown through said apertured pipes 21 to form with the gas which flows upwardly through the fluidized bed (and which has provided the desired treatment atmosphere) a stoichiometric mixture which is then ignited to form a kind of "fireball" just above said surface 15 and thereby heat the bed. Thus in the case of Figure 3, heat can be supplied from time to time from a "fireball" formed just above the bed whereas in the case of Figure 1 the additional heat will be supplied from combustion taking place within the upper part of the bed. In both cases however temperature control of the fluidized bed may be improved by blowing air upwardly over the exterior of the corrugated wall 12 and in the space between the corruguations and the insulation 13. Thus if it is required to operate the bed (after the initial warming up) at a given temperature then a fall of temperature below the given level can be corrected by admitting either air or gas, as the case may be, through the pipes 20 or 21 to provide combustion within or just above the upper part of the bed. On the other hand, a rise of temperature above th desired level

can be corrected by blowing cooling air over the exterior of said wall 12 as previously mentioned. If desired, the initiation of combustion and the introduction of cooling air can be controlled automatically by means of a thermostat arranged to maintain the desired temperature. Cooling air is also desirably supplied through ducts 22 beneath the container 10 in order to maintain the supporting structure of the fluidized bed, the underside of the porous tile 11 and the incoming gas and air mixture in a relatively cool condition.

A fluidized bed in accordance with the invention may be used as heat treatment apparatus as above described or alternatively it may be used to supply heat to an adjacent fluidized bed in which heat treatment is to be carried out. Thus for example there may be provided a three chamber construction in the form of a "sandwich" in which the heat treatment bed itself is disposed between a pair of further fluidized beds arranged to supply heat to the treatment bed. As a further alternative, a fluidized bed in accordance with the invention can be used as an incinerator for disposal of unwanted products or materials.

In all cases however, further protection is given to the porous tile 11 and associated fixing cement by arranging that a layer 8 of refractory particles 14 immediately adjacent to the tile is formed of coarser and/or denser particles than are used for the remainder of the bed. Thus, for example, said layer 8 of particles adjacent to the tile may be formed of Al_2O_3 particles of 1480μ (14 mesh) size, whereas the remainder of the bed may be formed of Al_2O_3 particles of 250μ (60 mesh) size, the nominal specific gravity of the Al_2O_3 particles being 3.96. A grid 9 is also preferably provided between said layer 8 and the conduit means 17 to prevent articles being treated from entering the lowermost part of the bed. The velocity of the gas flow through the bed can then be arranged in relation to said lowermost layer and the remainder of the particles so that the

smaller and/or lighter particles will be fluidized but the coarser and/or denser particles forming the bottom layer will not be fluidized. Said bottom layer will then provide a thermal insulation for the porous tile 11 which will also assist in keeping the upper surface of said tile at a relatively low temperature. Furthermore, as shown in Figures 1 and 3, the fluidized bed is provided with a removeable hood 23 which can be removed in order to insert articles into or remove them from the bed, said hood incorporating a baffle 24 and wire mesh 25 which, in use, serves to prevent the escape of refractory particles from the bed.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A fluidized bed comprising a container having a porous base and containing a mass of refractory particles, conduit means below said porous base for supplying to the underside thereof a non-combustible fluidizing medium whereby said medium can flow, when the bed is in use, through the porous base and into the mass of refractory particles, the layer of refractory particles immediately adjacent to said porous base being formed of denser and/or larger particles than the remainder of said refractory particles so that the particles of said layer do not become fluidized when said fluidizing medium is applied thereto, and further conduit means in said container disposed above and spaced from said porous base for introducing into the container a gaseous medium for use in establishing combustion for heating said mass of refractory particles.

2. A fluidized bed as claimed in claim 1, wherein said further conduit means is disposed adjacent to the upper surface of said mass of refractory particles when the latter are fluidized.

3. A fluidized bed as claimed in claim 2, wherein said further conduit means is disposed so that when in use combustion will be established within the upper part of the said mass of refractory particles.

4. A fluidized bed comprising a container having a porous base and containing a mass of refractory particles, conduit means below said porous base for supplying to the underside thereof a fluidizing medium whereby said medium can flow, when the bed is in use, through the porous base and into the mass of refractory particles, a layer of the refractory particles immediately adjacent to said porous base being formed of denser and/or larger particles than the remainder of said refractory particles so that the particles of said layer do not become fluidized when said fluidizing medium is applied

thereto, so that said porous base during use of said bed is thermally shielded by the unfludized layer of denser and/or larger particles from a fluidized heated layer of the refractory particles which exists above the unfluidized layer during such use.

5. The fluidized bed of claim 4 wherein said porous base comprises porous ceramic tile.

6. A method of heat treating articles by immersing them in a fluidized bed comprising a container having a porous base and containing a mass of refractory particles, comprising the steps of:

(a) arranging a layer of the refractory particles adjacent the porous base, such layer being of denser and/or larger particles than the remainder of said mass so as to remain unfluidized during use, the remainder of said mass of particles being fluidizable;

(b) supplying a gaseous fluidizing medium to the underside of said porous base and allowing said medium to flow therethrough and into said mass of refractory particles at a selected velocity as will leave said layer of denser and/or larger particles unfluidized while forming a fluidized layer thereabove from said remainder of the mass of refractory particles;

(c) maintaining the temperature of the fluidized layer of refractory particles at a selected elevated temperature with said porous base being thermally shielded from said fluidized layer by said unfluidized layer of denser and/or larger particles.

7. The method of claim 6 wherein said porous base comprises porous ceramic tile.

8. A method of heat treating articles by immersing them in a fluidiz d bed including a container having a base subject to thermal damage by way of which a

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flow of gaseous fluidizing medium can be supplied to the interior of said container and said container having therein a mass of refractory particles, comprising the steps of:

(a) arranging a layer of the refractory particles adjacent the base, such layer being of denser and/or larger particles than the remainder of the particles of said mass so as to remain unfluidized during use, the remainder of the particles of said mass being lighter and/or smaller than the particles of said layer;

(b) supplying said gaseous medium to said base such that a flow of said fluidizing medium is emitted therefrom and flows upwardly through said mass of refractory particles at a selected velocity such that said layer of denser and/or larger particles remains essentially unfluidized while a fluidized layer is formed thereabove from said remainder of the particles of said mass;

(c) maintaining the temperature of the fluidized layer of refractory particles at a selected elevated temperature with said base being thermally shielded from said fluidized layer by said unfluidized layer of denser and/or larger particles.

FIG.1.

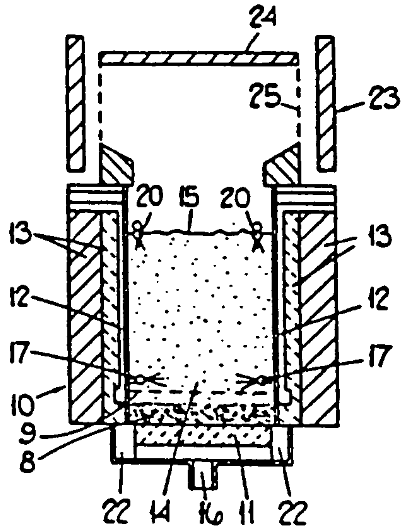


FIG.2.

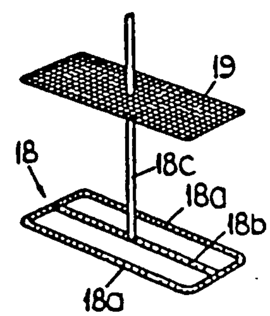


FIG.3.

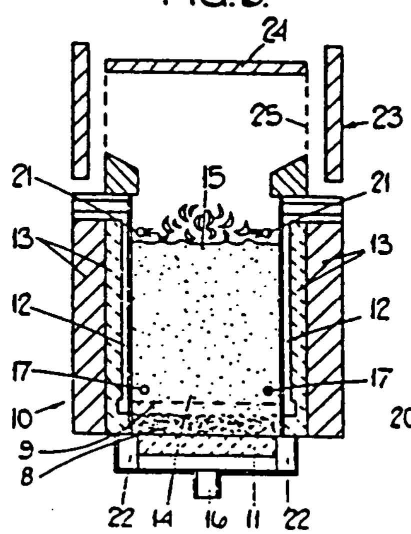
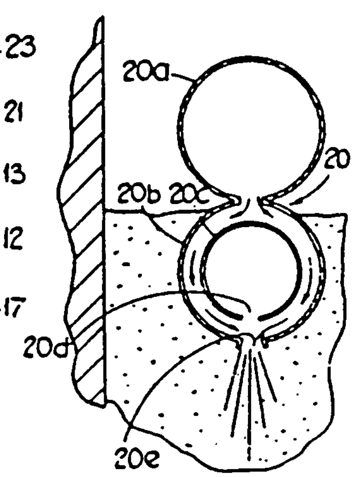


FIG.4.



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